Report Title: Habitat suitability index and performance of USACE sanctuary reefs in the Great Wicomico River

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Great Wicomico River

The Chesapeake Bay's native eastern oyster, *Crassostrea virginica*, is an ecosystem engineer that works hard filtering water, trapping and stabilizing sediment, and providing crucial habitat for other estuarine species.

Prior to the European colonization of North America, the native oyster population of Chesapeake Bay was described as being so abundant throughout the bay and its tributaries that oyster reefs posed a navigational hazard to ships. Currently, as a result of overharvesting, destructive fishing practices, disease, and poor water quality, the native oyster population of the Chesapeake Bay now stands at less than 1 percent of its historic population size. Much of its original reef acreage has been lost, and what remains is in mostly poor condition.

In 2004, the U. S. Army Corps of Engineers, in conjunction with the Virginia Institute of Marine Science and other federal and state agencies, constructed 85 acres of "no take" sanctuary oyster reef habitat in the Great Wicomico River, a small tidal tributary of the Chesapeake Bay, located approximately 60 miles northeast of Richmond, Va.

This waterway was chosen because it is a "trap" estuary where water movement promotes the circulation and eventual settling of larvae generated by the spawning of oysters living within the river's reef network. It had a history of high oyster spatsets (baby oysters are known as "spat") relative to most of the rest of the bay due to this.

Modern-day modeling has identified that it has favorable hydrodynamics for oyster larval retention – which is what gives it the "trap" nature noted decades earlier. The Corps focuses on developing a sufficient network of oyster reefs to reestablish the historic population by producing enough oyster larvae to replenish the constructed reefs and to be carried by currents to other locations in the river.

Monitoring data provides strong evidence that this has occurred, with a positive increase in river-wide recruitment first noted in 2006 and continuing today. In fact, in the GWR, 2012 had the highest oyster recruitment ever observed in the Bay since monitoring began in the 1940s.

The project focuses on the development and validation of a high-resolution Habitat Suitability Index, or HSI, for the eastern oyster in this waterway. The model was intended to aid in the identification of suitable areas for both the rehabilitation of the existing sanctuary oyster reef network and the construction of additional oyster reefs. Researchers utilized maps of historic oyster reef locations and hydrodynamic models to identify suitable locations in the river for oyster reef placement and stock enhancement. In addition, the environmental and physical factors (such as sea bottom type, water depth, and salinity variables) controlling the distribution of oyster populations had to be determined. These were then reclassified according to physiological tolerances, and analyzed within a Geographic Information System. Data cells were classified on a

gradient between 0, indicating highly unsuitable habitat, and 1, indicating highly suitable habitat, with varying degrees of suitability in between. The information derived from the HSI was then incorporated with information derived from other tools to determine optimal placement for the sanctuary reefs.

In 2009, President Obama implemented Executive Order 13508 – a strategy for protecting and restoring the Chesapeake Bay watershed. One of the key goals of the executive order is to restore native oyster populations in 20 tributaries of the Chesapeake Bay by 2025. The federal agency entrusted with oyster restoration under the Executive Order is the U.S. Army Corps of Engineers, and the criteria used to define successful restoration (i.e., a live adult oyster density of 50 m^{-2}) are derived from the findings of the Sustainable Fisheries Goal Implementation Team of the Chesapeake Bay Program.

After seven years, the HSI was tested in 2011 using adult oyster density data collected from both high-relief reefs and low-relief reefs in the sanctuary network. For HSI values greater than 0.3, all HRR reef samples exceeded the fisheries goal implementation team's restoration target of 50 adults m^{-2}, whereas for low relief reef samples 73 percent of reef samples were above the target. For HSI less than 0.3, high relief reefs had 80 percent of samples exceeded the target, whereas on low relief reefs only 13 percent of the samples met the target.

Oyster densities were much higher on the high relief reefs relative to the low relief reefs in almost all cases, providing further support to building reefs at high relief provides better habitat for the native oyster. Sampling in the spring of 2013 indicated high recruitment and in the summer and fall of 2012, sampling indicated an increase in numbers of live oysters on high relief reefs, where large numbers of adults were also still present.

Thus, the sanctuary reef network in the GWR reflects successful long-term native oyster restoration, when constructed on suitable habitat. The HSI is a strong indicator of reef performance and can be modified for use in other locations and for other native oyster species. The HSI shows that suitable habitat and design is essential for reef performance and that there remains large areas of suitable habitat for restoration in the GWR.

Integration of robust HSIs into site selection plans for native oyster restoration efforts in Chesapeake Bay and other bodies of water should become common practice. These HSIs should account for and incorporate all relevant and necessary environmental and physical variables controlling the distribution of oysters. Sources of information, such as recent, high-resolution datasets; maps of historic oyster reef locations; hydrodynamic models; and land use patterns should be utilized to determine optimal locations to construct oyster reef.